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THE IMPORTANCE OF COMPUTERS IN AEROSPACE TECHNOLOGY

Walter B. Olstad
NASA OAST
(Acting) Associate Administrator

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This symposium marks an important event in the development of the Integrated Programs for Aerospace-Vehicle Design (IPAD); namely, the impending release of a major IPAD software package for evaluation by potential users. It is also significant that this symposium links IPAD with the issue of increased productivity, because productivity has recently become a topic of great national concern. In his presentation, Norman Augustine specifically and very effectively addresses this topic. This paper will attempt to show how computer technology has already and, in the near future, will to a much greater extent expand man's capabilities by relieving him of much tedious and repetitive work, by permitting him to quickly and accurately analyze a variety of situations or options in order to make critical decisions, by furnishing a facility for the storage and rapid retrieval of valuable information, and by providing the critical means for extending man's thoughts, vision, and physical activity into often otherwise inaccessible or hostile environments.

Today in the aerospace industry, and indeed in many others, the computer plays a very significant and, not fully appreciated, pervasive role in all phases of technology from the most fundamental research, through design and manufacturing, to marketing, operations, and maintenance. Fields of technology and science have been revolutionized by the computer. Outstanding early examples were the fields of ballistics and nuclear weapons research. Added to this list have been the fields of structural analysis, acoustics, quantum physics, molecular properties, chemical kinetics, fluid mechanics, heat transfer, astrophysics, climatology, meteorology, solid state physics, electronic circuit theory, and many more; in fact, in all fields which have a sound theoretical basis. Furthermore, the accumulation and analysis of statistics promise to lead to a more sound theoretical basis in many of those fields where such a basis has been lacking. Clearly, the computer has expanded man's capabilities as a scientist and engineer many times over. He now contemplates and undertakes activities which would be impossible without it. The exploration of our planetary neighbors is just one example.

The computer can greatly enhance the effectiveness and productivity of the designer. While this is an obvious statement to make to this audience, it is nonetheless likely that few, if any, realize the extent to which that enhancement will be realized. It is a failing of our species that we are inclined to be overly optimistic about achievements in the near term, but woefully pessimistic about longer term accomplishments.

In fact, the use of the computer as a design aid is well established. Sophisticated computational algorithms have been developed in the various technical disciplines that support the design process, enabling that process to synthesize the components and subsystems of the design products, and predict their performance characteristics far in advance of their physical implementation Recent advances in computer graphics have transformed the working environment of the designer from the drafting table to the CRT terminal. Notwithstanding these significant developments, there persists a trend toward increasing design work load per unit weight, as depicted in figure 1. The cost trends, also shown in the figure, indicate increasing labor costs with time, in contrast to the decreasing computer cost trend. Clearly, then, use of the computer to increase the productivity of the design team should be extremely cost-effective and should eventually lead to a reversal of the design team man-hours trend. This will occur provided, of course, that man and the computer are in roles in which each is the most productive.

A careful scrutiny of the design process in the early seventies identified information handling, besides graphics and technical analysis, as an area where the computer had an effective role. As depicted in figure 2, aerospace product design involves a considerable amount of data communication among the designers, the supporting technical disciplines, and design management. While the generation and interpretation of the data require the unique skills of the team members, the handling of the data storage, retrieval, updating, and transfer among users is routine and well suited to automation.

Figure 3 is a more specific illustration of the flow of information among the various analysis and configuration definition functions involved in an airfoil design system, developed at the Pratt and Whitney Aircraft Group. Through the use of a central airfoil data library for integrating the various functions, significant reductions have been realized in both the man-hour and lead time requirements. Use of a central data library also promotes more effective control of information updating and versioning and assures that all members of the design team are working with current and relevant data. This would tend to minimize, if not eliminate, one major source of design errors, which often show up very late in the product development cycle and must be covered with costly engineering change orders. Thus the use of computer technology in the design process, commonly known as computer-aided design or CAD, has a direct impact on manufacturing costs through the reduction of designer workload and reductions in out-of-sequence design changes, information preparation, and manufacturing rework.

The role of the computer in the manufacturing of aerospace products is also very important and well established, although still in its infancy. Complex milling, cutting, forming, and drilling machines operating under direct control of computers today are becoming more common in the machine shops and on the assembly floors of many aerospace companies. Indications are clear that computer-aided manufacturing (CAM) will continue to grow in the level of automation and versatility of the machines and their controllers. Since the data used by the computers to control the manufacturing equipment are derived from those generated in design, the issue of data flow can be seen to be important not only in the design phase, but also in the interface between design and manufacturing. Indeed, we may look to the future for integrated CAD/CAM systems, such as that shown in figure 4, in which the key design and manufacturing activities are integrated via a shared data base.

While the potential benefits of CAD/CAM are immense, the technological risks and initial costs involved in developing major capabilities are also quite high. Consequently, direct government involvement is desirable if significant progress is to be achieved. Industry has been building its capabilities on an incremental basis since the sixties, using available and proven technology. In 1976, NASA undertook the development of IPAD to provide advances in CAD technology that would be needed in the eighties. At about the same time, the Air Force initiated the Integrated Computer-Aided Manufacturing (ICAM) effort to provide a national focus in CAM technology. Figure 5 gives one perspective of an ICAM factory.

The IPAD project is depicted graphically in figure 6. With the direct involvement of a large segment of the aerospace industry, the Industry Technical Advisory Board (ITAB), the project has defined the major elements of an ideal system, has selected a subset for implementation as a limited capability but representative prototype, and is about to release this first major software package later this year. Along the way to this milestone, a number of useful products have been produced, which will be discussed in the course of this symposium. It is also noteworthy that NASA has already employed the IPAD design drafting software in its programs. Figure 7 illustrates one such application involving the conceptual design and analysis of a large area truss platform configuration for space applications.

Both NASA and the Air Force recognized the need for IPAD and ICAM to have compatible interfaces and have taken steps to ensure this through facilities for interaction among the various parties involved. Figure 8 depicts these interactions. It is evident from the chart the extent to which industry is involved in both programs. In fact, both programs are viewed as being joint government/industry undertakings, and as we approach the release of major IPAD software, it is confidently expected that the cooperation between NASA and industry which has carried the program to this point will continue so that together we can achieve the goals that we have set.

Before closing, there is one disturbing trend that deserves our attention. That is the rapid growth of software costs. It is paradoxical that a field of technology which holds such promise for relieving man of tedious chores and for multiplying his capabilities many times over is beginning to be dominated by the costs of, what is now a labor intensive activity, software development. It is both essential that this problem be vigorously attacked now and obvious that the solution to the problem will be found in computer technology itself. In fact, it is clear that the very elements that can lead to successful computer-aided design programs can be used in the development of computer-aided software design programs.

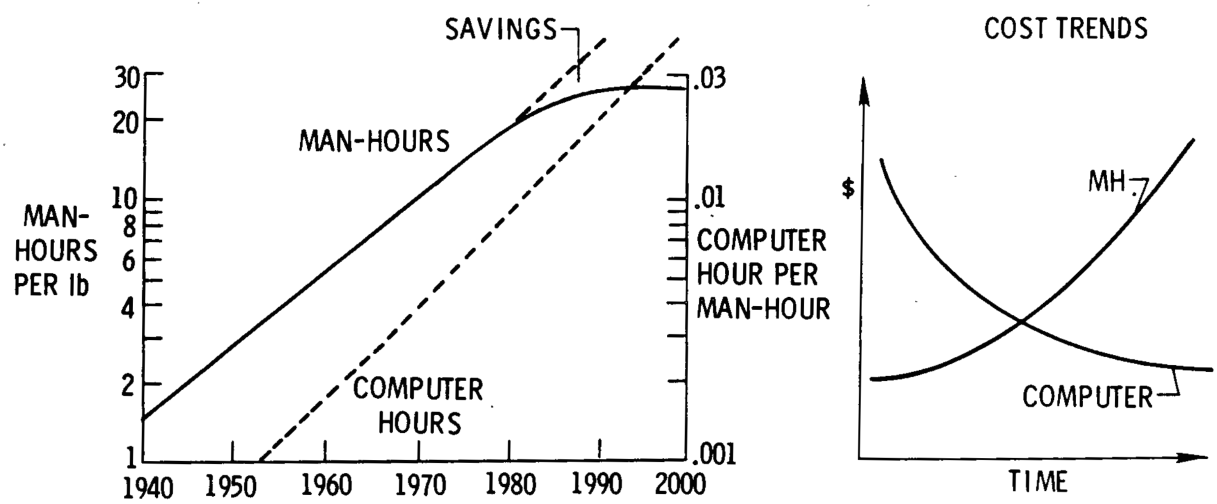


Figure 1.- Potential impact of computer-aided design (CAD) on design cost (1 man-hour per lb = 2.22 man-hours per kg).

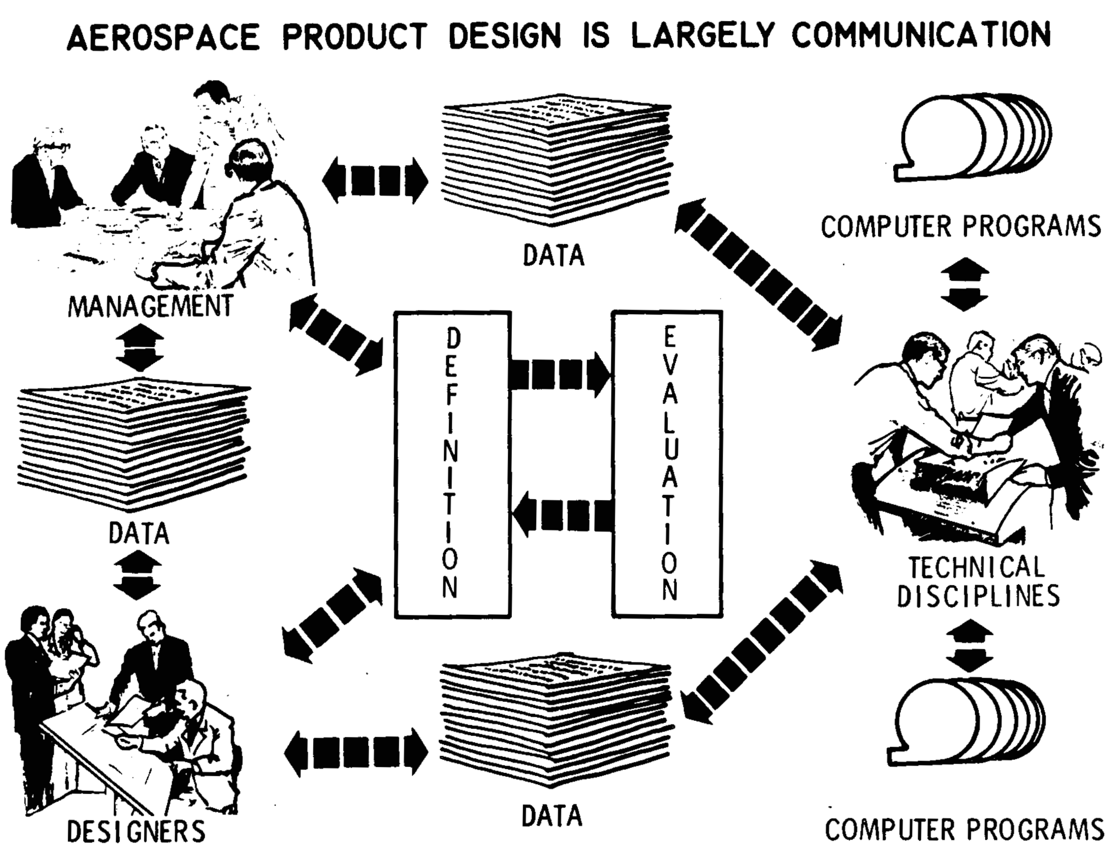


Figure 2.- Data communication aspects in aerospace design.

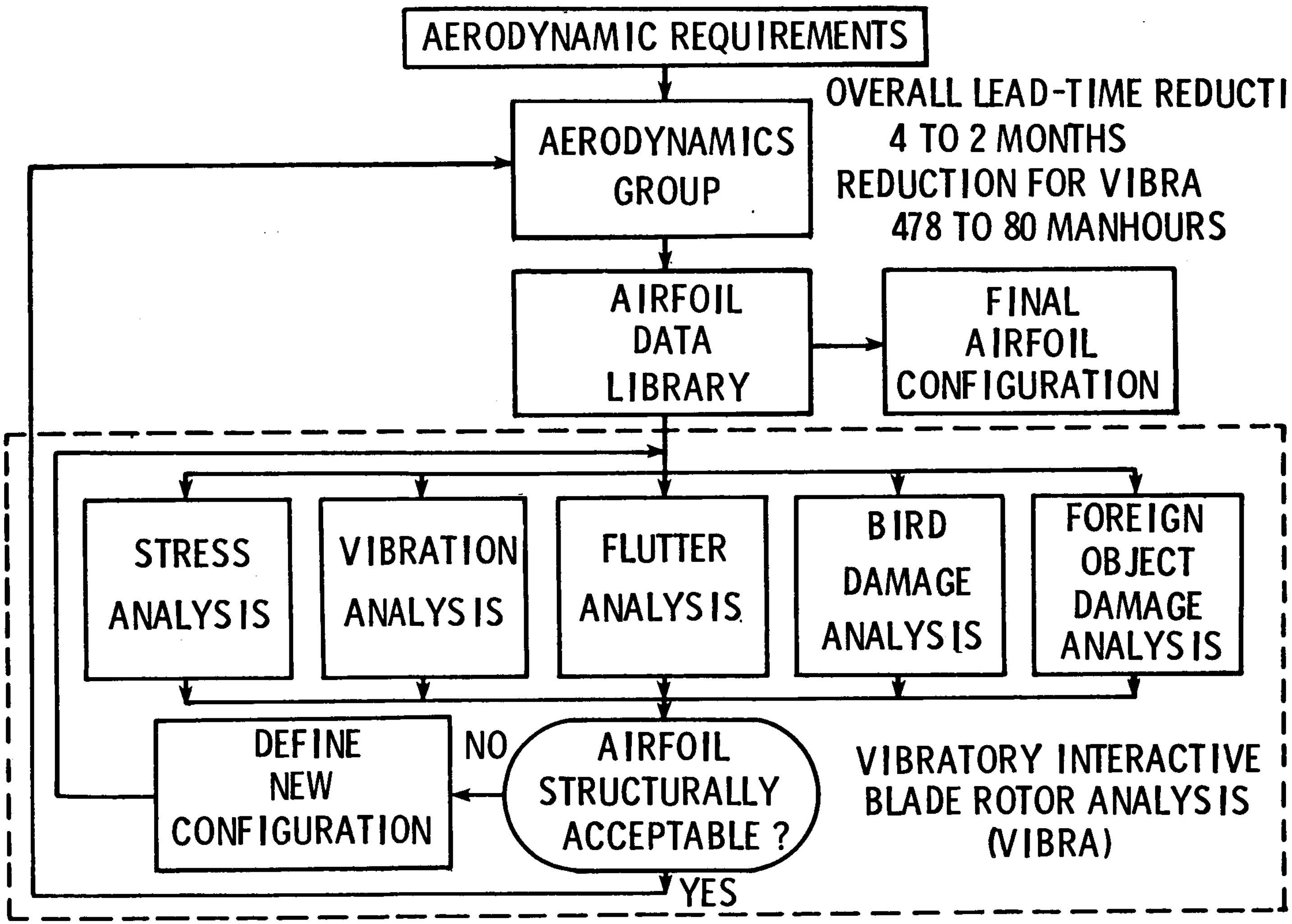


Figure 3.- Typical information flow in airfoil analysis and design (courtesy of Pratt and Whitney).

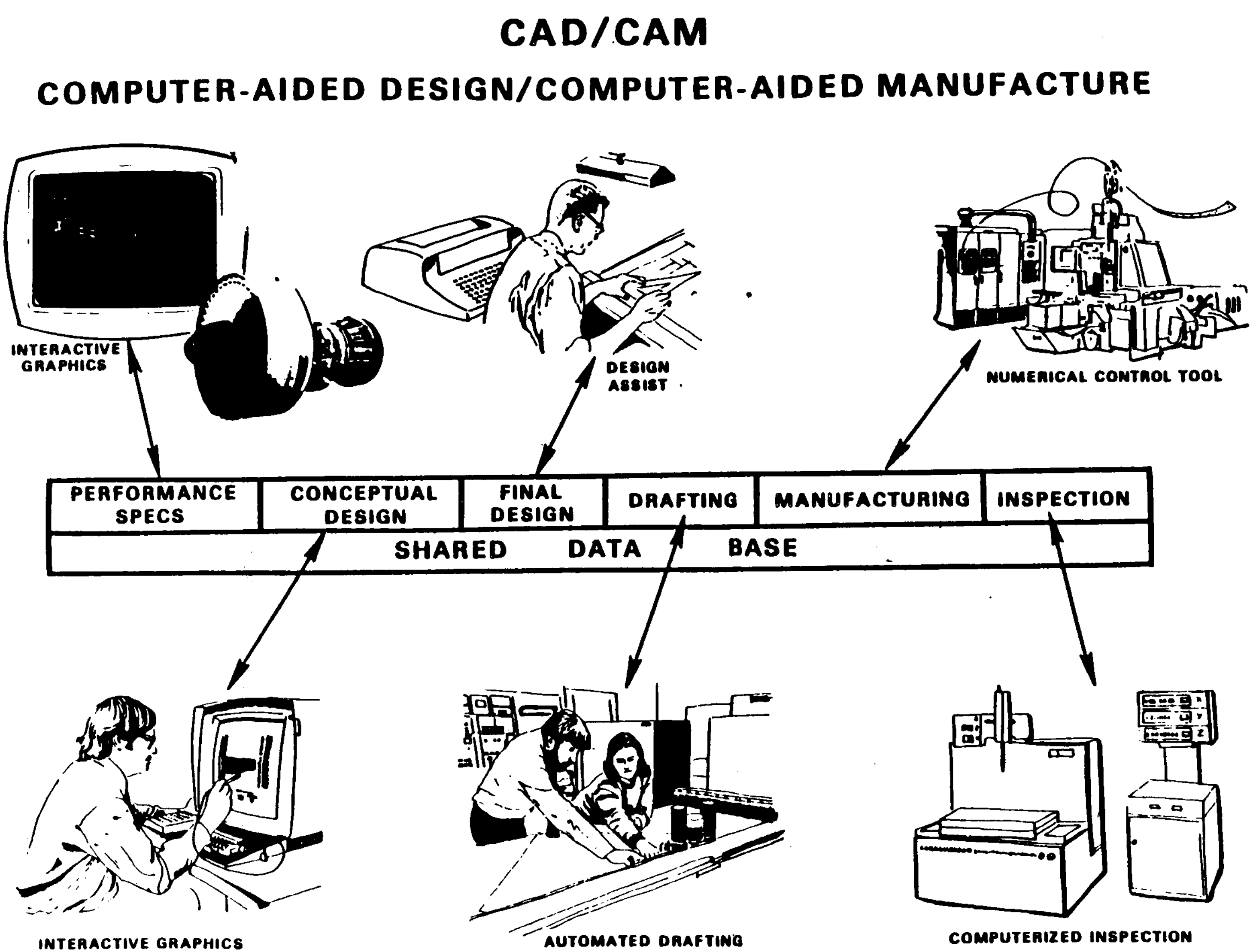


Figure 4.- Future integrated CAD/CAM systems.

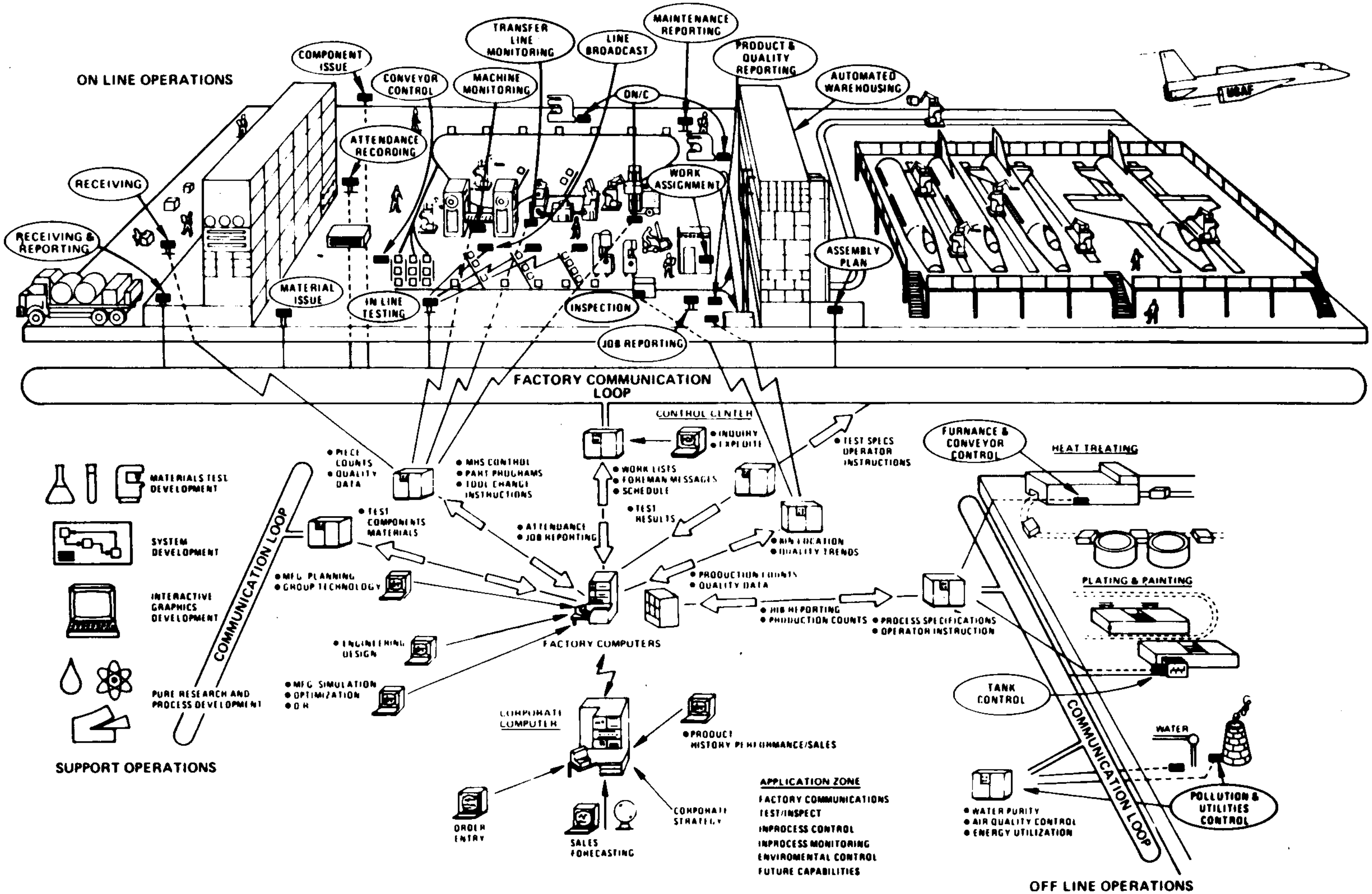
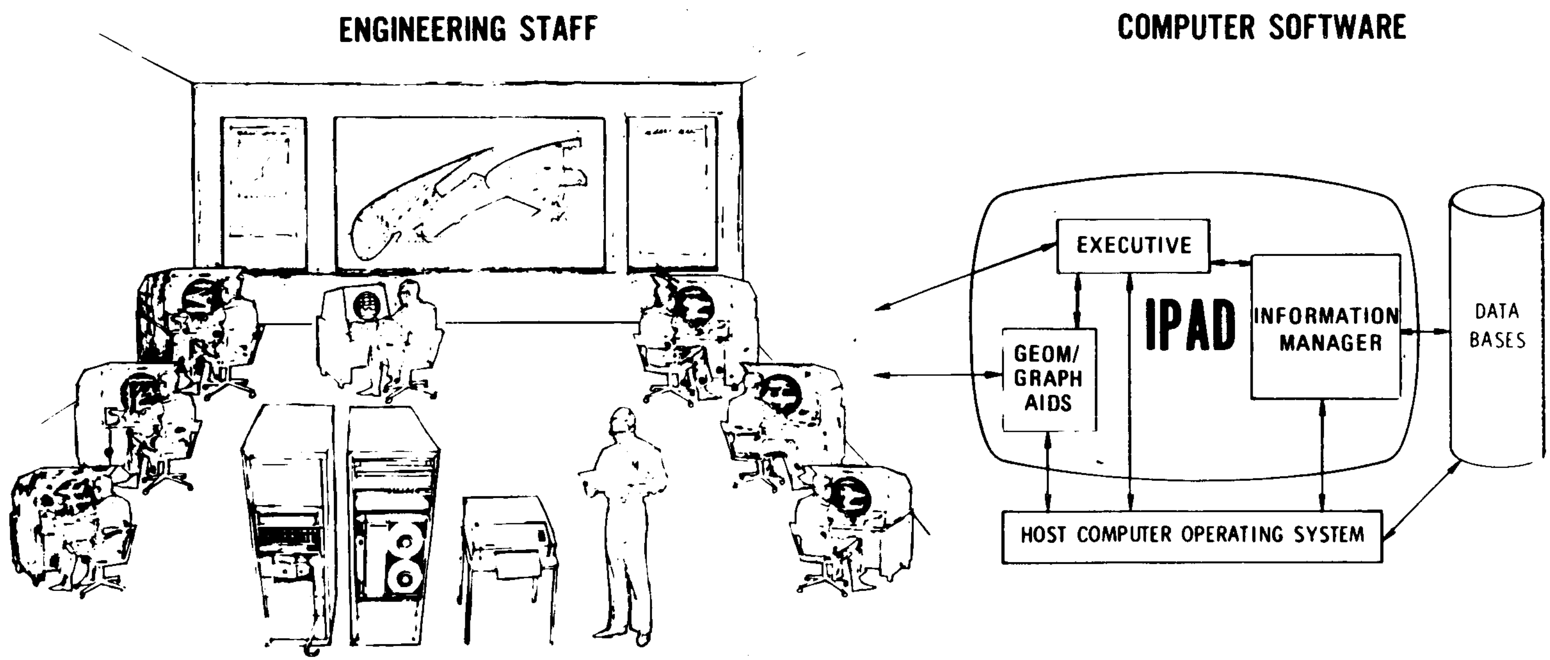


Figure 5.- The Air Force Integrated Computer-Aided Manufacturing (ICAM) Program.

COMPUTER TECHNOLOGY FOR INTEGRATED, COMPANY-WIDE MANAGEMENT
OF DESIGN DATA AND COMPUTER PROGRAMS



- $15M, 5 YEAR DEVELOPMENT PLAN
- INCREMENTALLY DEVELOPED FOR 2 DIFFERENT COMPUTERS
- HEAVY INDUSTRY INVOLVEMENT

Figure 6.- The NASA Integrated Programs for Aerospace-Vehicle Design (IPAD) Project.

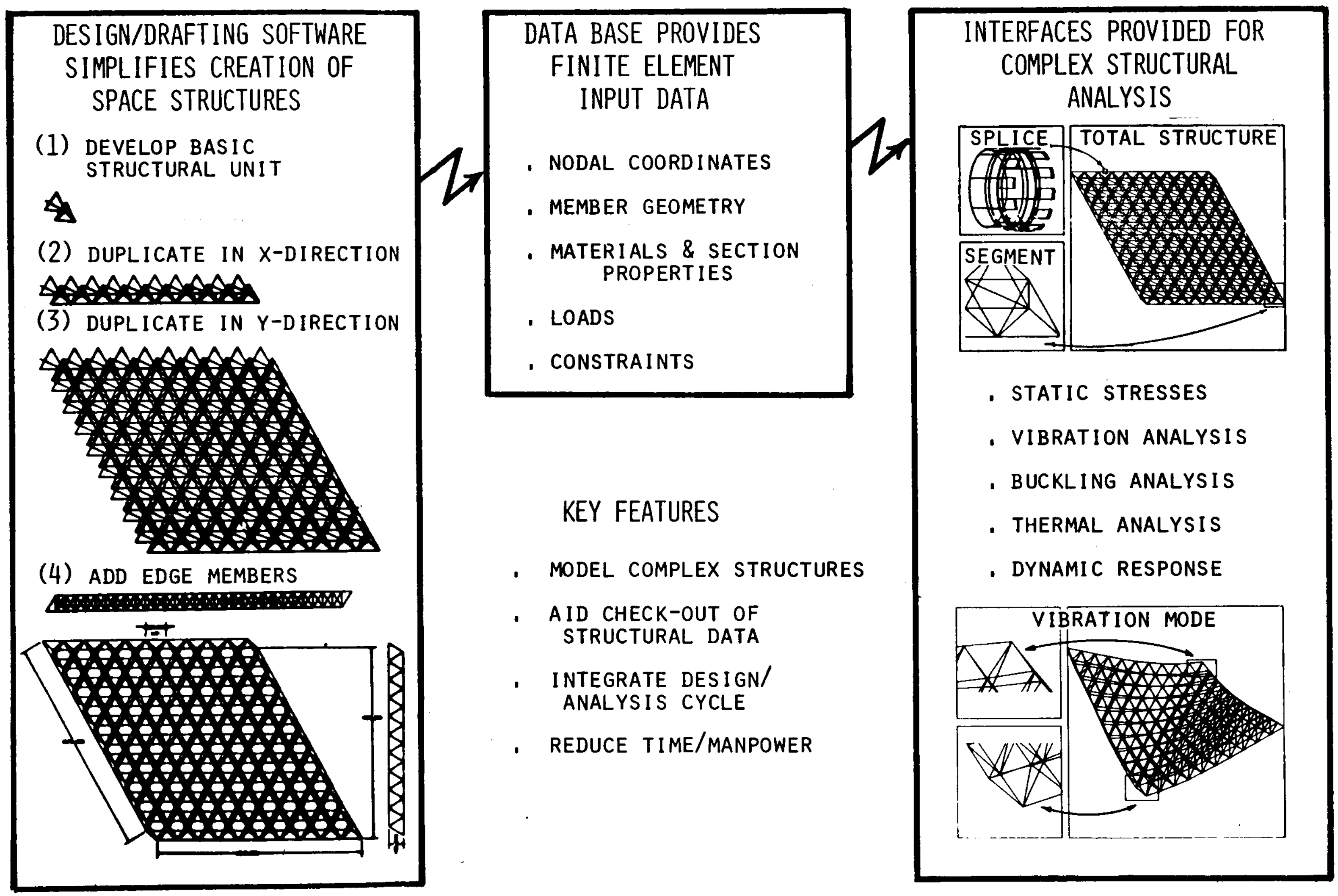


Figure 7.- Use of IPAD software to integrate large area space structure design/analysis tasks.

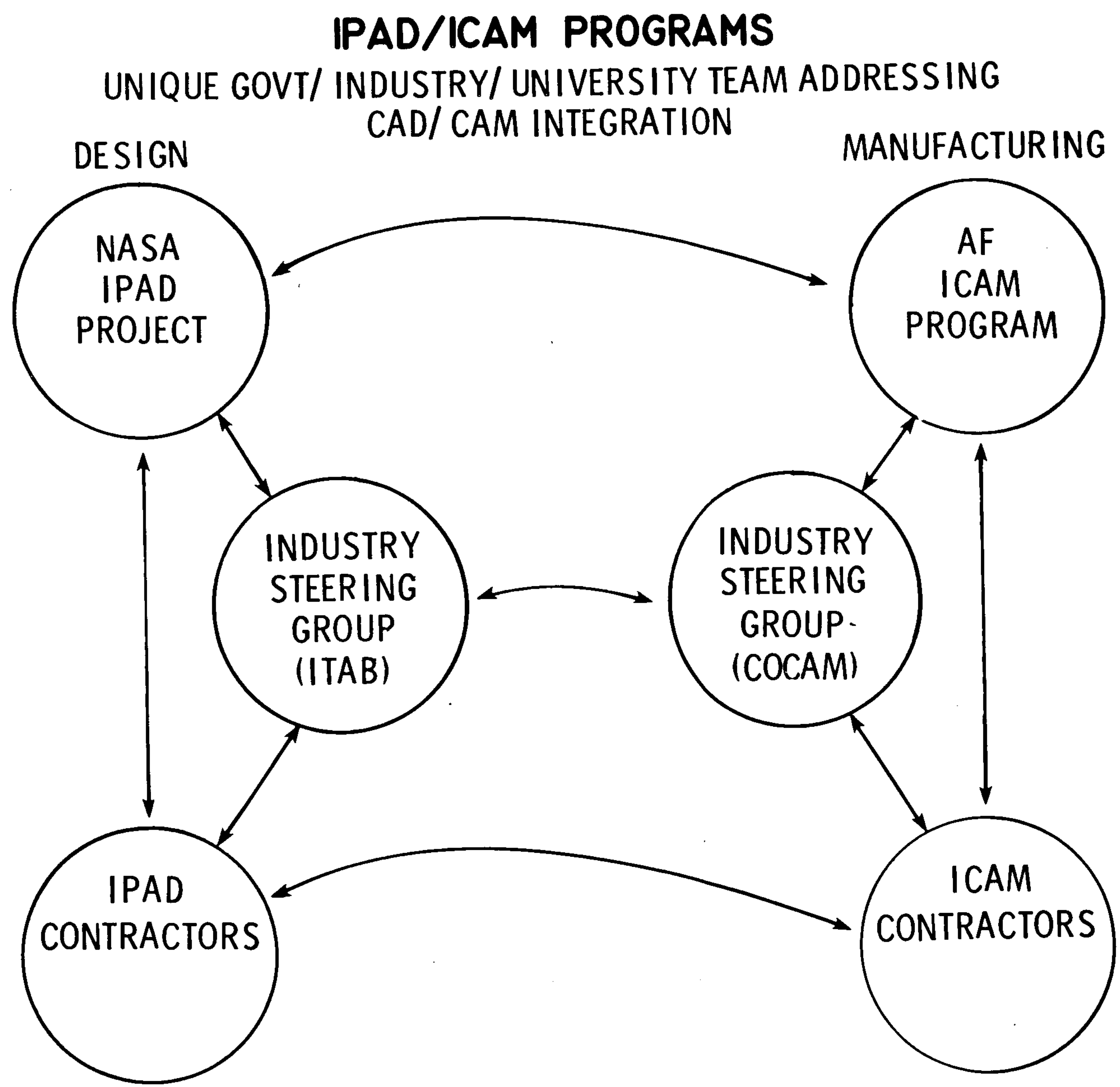


Figure 8.- Key ICAM/IPAD interactions.